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Xenoderm Versus 1% Silver Sulfadiazine in Partial-thickness Burns

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OBJECTIVE: The aim of this clinical trial was to evaluate the effectiveness of using lyophilised porcine skin (Xenoderm) compared with 1% silver sulfadiazine (SSD) in partial-thickness burns with regard to wound infection, length of hospital stay, number of dressings and doses of analgesics used (oral and injection).

METHODS: A total of 78 burns patients were included in this randomised study; their burns were caused by scalds or flames. They had second degree burns and had a burn area of 10–60% of total body surface area (TBSA). Thirty-seven patients were treated with daily washing, followed by topical application of SSD dressing (the SSD group) and 39 with a biological dressing, i.e. Xenoderm (the Xenoderm group). The differences were evaluated using unpaired Student's *t*-test, Mann-Whitney U test and Chi-square test.

RESULTS: There were no significant differences between the two groups with respect to age, gender, TBSA, cause of burn, and thickness of the burn or burn site. But there were significant differences regarding degree of wound infection, length of hospital stay, number of used dressings and given doses of analgesics.

CONCLUSION: Xenoderm seems to be more effective than SSD dressing in terms of pain control, degree of wound infection, used wound dressings and length of hospital stay for partial-thickness burns. Prospective randomised studies are now necessary to compare possible reductions in the use of split thickness skin grafts and re-epithelialisation times. [*Asian J Surg* 2009;32(4):234–9]

Key Words: biological dressing, partial-thickness burns, silver sulfadiazine, Xenoderm

Introduction

Burns have always been a tragedy for man. It has significant morbidity and, often, significant mortality.[1–3] For many years, partial-thickness burns have been treated by daily washing and cleaning of the wound, followed by a topical application of antimicrobial cream. However, the pain suffered and impaired wound healing remain problems to be addressed.[4] Superficial partial-thickness burns (2nd A degree) often heal in 3 weeks, whereas deep partial-thickness burns (2nd B degree) and full-thickness burns (3rd degree), which can be treated by early excision and grafting, take several weeks to heal.[3,5] It is agreed that the best way to treat deep partial-thickness burns and 3rd degree burns is early dermabrasion, or escharectomy, followed by coverage with skin graft.[6]

Few studies have compared the effectiveness of biological dressings in partial-thickness burns.[3,7–9] Allograft, synthetic and biological dressings are an integral part of modern burns care. Today, lyophilised porcine dermis

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(i.e. a xenograft) has gained acceptance as a temporary dressing[10–12] and is considered an alternative to antimicrobial dressings.[3,10,11]

Xenoderm is a new product derived from lyophilised porcine dermis. The advantages of lyophilised porcine skin are its greater adherence to wounds (3–5 weeks), decrease in pain, evaporative water, heat loss, protein loss, electrolyte loss, and lower hospital costs.[9,10,12–14] In addition to these, the skin can heal faster, with less scar formation, and fewer infections.[10,14,15] On the other hand, the disadvantages of Xenoderm are a theoretical risk of zoonosis and ethical/religious issues.[14,16] Up to now, few descriptive studies have been conducted regarding lyophilised porcine skin (Xenoderm) in developing countries.[16]

For many decades, 1% silver sulfadiazine (SSD) has been used to treat burns and chronic wounds. Topical silver cream has a broad spectrum of antimicrobial activity, low development of bacterial resistance, few adverse reactions and a low risk of systemic toxicity. However, it requires frequent application, is care intensive to apply and remove, and is sometimes painful.[3,17]

Unfortunately, nowadays many patients with deep partial-thickness burns (2nd B degree) are treated by daily washing and SSD dressing in many burns centres in developing countries. Although recent studies have supported the application of biological dressings in developing and Islamic countries, their application is still not common. The aim of this clinical trial was to evaluate the effectiveness of Xenoderm compared with SSD in partial-thickness burns with regard to wound infection, length of hospital stay, number of dressings and doses of analgesics used (whether oral or injection).

Patients and Methods

In this prospective randomised clinical trial, 78 burns patients of Shafieeh Hospital in Zanjan (Iran) were investigated between March 2006 and November 2007. These patients with partial-thickness burns who entered the study had a burn area of 10–60% of total body surface area (TBSA) caused by scalding or flames. Patients who had 3rd degree burns (contact burn and others), already present infection, contaminated wounds (with chemical or faecal material, or soil), comorbid diseases, fractures, neurological injury or who were pregnant were excluded from the study. The depth of burn was very important for surveillance and management planning, thus all patients in this study had 2nd degree burns. Informed consent was obtained from all patients before they were included in the study. The patients were randomly divided into two groups consecutively. The first group (i.e. the SSD group) was treated daily with washing and cleaning, followed by topical application of 1% SSD dressing. The second group (i.e. the Xenoderm group) was treated with the biological dressing, Xenoderm, a new product of lyophilised pig skin manufactured by Medical Biomaterial Products (Berlin, Germany).

In the Xenoderm group, Xenoderm was prepared in normal saline solution. Then, after tangential excision or dermabrasion of the burned area, with a dermatome and rinsing the wound with normal saline, Xenoderm was placed on the wound by the surgeon and fixed in place using a suture, dressing, or bandage. All patients received cefazolin (antibiotic) prophylaxis. Afterwards, the burned region was immobilised by a splint if necessary. Twenty-four hours after the surgery, the dressing was removed. Following this process, after 2–5 weeks Xenoderm was sloughed spontaneously.

The discharge criteria for both groups of patients were: the ability to tolerate dressing changes, using only oral pain medications and the caregiver's ability to perform necessary dressing changes.

All data, including demographics, mechanisms of injury, depth of burns, burn area (percentage of TBSA), location of burns, length of hospital stay, doses of analgesics given (whether oral or injection, the number of dressings used, intravenous (IV) fluid administration (before oral intake by patients), inhalation injury (facial burns, mucosal oedema and wheezing), wound infection (secretion of pus) and mortality, were measured by the physicians and general surgeons of the Burns Department of Ayatollah-Mousavi Hospital. Significant differences were evaluated using the unpaired Student's *t* test, Mann-Whitney U test and Chi-square test. A p value of less than 0.05 was deemed to be significant. All analyses were performed using SPSS 11.5 (SPSS Inc., Chicago, IL, USA). Finally, our study was approved by the Ethics Committee of Zanjan University of Medical Sciences.

Results

A total of 78 burns patients were randomly divided into two groups. Two patients in the SSD group left the hospital 2 days after admission and, consequently, were

Table 1. Patients' demographic characteristics

	SSD group ($n = 37$)	Xenoderm group ($n = 39$)	p
Male	24 (64.9%)	26 (66.7%)	NS
Female	13 (35.1%)	13 (33.3%)	NS
Mean age, yr (range)	24.9 (1–67)	18.9 (1–74)	NS
Mechanism of injury			NS
Scalding	15 (40.5%)	20 (51.3%)	
Flames	22 (59.5%)	19 (48.7%)	
Inhalation injury	6 (16.2%)	11 (28.2%)	
Mean burn area, % TBSA (range)	16.4% (10–54%)	17.6% (10–45%)	NS
Depth of burn			NS
2nd A degree	9 (24.3%)	6 (15.4%)	
2nd A & 2nd B degree	19 (51.4%)	21 (53.8%)	
2nd & 3rd degree	9 (24.3%)	12 (30.8%)	
Location of burn			
Face	15 (40.5%)	19 (48.7%)	NS
Neck	7 (18.9%)	13 (33.3%)	NS
Body	12 (32.4%)	16 (41%)	NS
Upper limbs	23 (62.1%)	20 (51.2%)	NS
Lower limbs	18 (48.6%)	25 (64.1%)	NS
Genital area	1 (2.7%)	8 (20.5%)	–
Total wound infection	15 (40.5%)	7 (17.9%)	–
Zoonosis	–	2 (5.1%)	–

SSD = 1% silver sulfadiazine dressing; TBSA = total body surface area; NS = non significant.

excluded from the study. So, 37 patients were in the SSD group and 39 in the Xenoderm group. There were no significant differences between the two groups with respect to age, gender, % TBSA, cause of burn, burn thickness or burn site (Table 1). In the SSD and Xenoderm groups, 81.1% and 94.9% of the patients, respectively, were admitted on the same day on which they were burned. The mean duration from being burned up to using Xenoderm was 1.77 ± 0.93 days. Thirty (76.9%) patients underwent surgery and were covered with Xenoderm within the first 48 hours.

Inhalation injuries (respiratory burns) in the SSD group were lower than in the Xenoderm group. The most commonly burned areas were the upper limbs, lower limbs and face in both groups. Neck and genital region burns were more common in the Xenoderm group than in the SSD group (13 *vs.* 7 and 8 *vs.* 1 respectively) (Table 1).

There were significant differences regarding degree of wound infection, length of hospital stay, number of used dressings and given doses of analgesics. Other comparators did not show any significant difference between the two groups (Table 2).

There were wound infections in two (5.1%) patients in the Xenoderm group and in 12 (32.4%) patients in the SSD group during their hospital stays. The rate of infection for neck wounds was higher than for other parts of the body in both groups. Follow-up 5 weeks later showed that the total wound infection rates in the Xenoderm and SSD groups were 17.9% (7 patients) and 40.5% (15 patients) respectively ($p = 0.03$). These patients were treated with split thickness skin grafts (STSG). Fifteen (38.4%) patients with a mean burn area of 14.7% TBSA in the SSD group and 31 (83.7%) patients with a mean burn area of 17.2% TBSA in the Xenoderm group were discharged from the hospital in less than 1 week.

In the Xenoderm group, the mean number of dressings used between the initial time of referral to hospital and surgery was 1.97 (range, 1–4). After using Xenoderm,

Table 2. Effect of treatment on various clinical parameters in patients

Variable	Group	*n*	Mean (SD)	Median	*p*
Age	1% Silver sulfadiazine	37	24.9 (18.7)	23	0.09
	Xenoderm	39	18.9 (20.1)	15	
Burn area (% TBSA)	1% Silver sulfadiazine	37	16.4 (9.1)	13	0.43
	1% Xenoderm	39	17.7 (8.3)	16	
Number of dressings	1% Silver sulfadiazine	37	10.9 (9.2)	8	0.0005
	Xenoderm	39	3.2 (4.4)	2	
Number of analgesics (IV)	1% Silver sulfadiazine	37	4.08 (12.2)	2	0.02
	Xenoderm	39	0.92 (0.9)	1	
Number of analgesics (oral)	1% Silver sulfadiazine	37	11.5 (15.5)	7	0.0005
	Xenoderm	39	4.5 (5.3)	3	
First hospital stay (d)	1% Silver sulfadiazine	37	11.2 (9.3)	8	0.003
	Xenoderm	39	6.3 (4.6)	5	
IV serum before oral intake	1% Silver sulfadiazine	37	4.9 (6.2)	2	0.98
	Xenoderm	39	3.7 (3.7)	2	

SD = standard deviation; TBSA = total body surface area; IV = intravenous.

this number was 1.26 (range, 0–25). In the Xenoderm group, 23 (58.9%) patients did not use any other dressings, 14 (35.8%) patients used only one dressing, and two patients used more than 10 dressings after using Xenoderm because of wound infection. In the SSD group, 15 patients used dressings more than ten times.

In the SSD and Xenoderm groups, 32.4% and 38.4% of the patients, respectively, did not use any injected analgesics. The results of taking oral analgesics indicated that 62% of patients in the SSD group and 23% of patients in the Xenoderm group used more than six doses. The median number of analgesics were seven and three for the SSD group and Xenoderm group respectively.

Detaching Xenoderm from the burn site began from the 2nd week and continued up to the 5th week (Figures 1–3). However, if the Xenoderm did not detach after 5 weeks, it was considered to indicate the presence of zoonosis (the Xenoderm was not rejected by the recipient site). This occurred in two patients with very deep partial-thickness burns. The most common sites were the legs in this case. These patients were treated by excision of the Xenoderm and grafting STSG.

Figure 1. Attachment and detachment of Xenoderm on the 18th day of Xenoderm usage.

Discussion

The present study supports the hypothesis that application of Xenoderm, as compared to SSD, leads to a reduction in wound infection rate, length of hospital stay, dressing changes and use of oral analgesics.

The results showed us that in the SSD group, the wound infection rate (during the hospital stay plus the 5-week follow-up) was greater than in the Xenoderm group (40.5% *vs.* 17.9%). Most of the infections in the Xenoderm group occurred in patients who had suffered burns in the "wrinkly" parts of their bodies, such as neck, axilla and groin. This caused the Xenoderm to detach from the burn site earlier than expected, leading to infection. Joining Xenoderm to the wound led to a

Figure 2. Attachment and detachment of Xenoderm on the 24th day of Xenoderm usage.

Figure 3. Attachment and detachment of Xenoderm on the 52nd day of Xenoderm usage.

restriction of potential "necrotic space" and a prevention of hematoma and seroma that could otherwise cause infection.[11] Hence, Xenoderm acts as a physical barrier against excessive bacterial growth.[18–20] Gravante et al reported that a biological dressing guarantees a temporary barrier function, avoiding vapour loss whilst reducing bacterial invasion (the infection rate decreased from 29.5% to 10%).[21] Also, some studies have reported that when using SSD, there were more wound infections than when using a biological dressing.[8,21,22] As you can see in our study, the infection rate during hospital stay was 32.4% in the SSD group versus 5.1% in the Xenoderm group. These results are not much different from Gravante et al's study. One of the reasons for the increase in infection rate in patients after hospital discharge is further contamination. The other is the exact record of small wounds in the wrinkly parts of the body.

The length of hospital stay in the SSD group was longer than in the Xenoderm group; 83.7% of the patients in the Xenoderm group (with a mean burn area of 17.2% TBSA) were discharged from hospital in less than 1 week. This short hospital stay was due to faster re-epithelialisation, reduction of wound infection and fewer wound dressing changes. Hosseini et al reported that the mean length of hospital stay for 2nd degree burns (with a mean burn area of 16.8% TBSA) which were treated with Xenoderm dressing was 6.45 ± 5.51 days.[16] Other studies have reported that using biological or synthetic dressings can reduce the length of hospital stay in 2nd degree burns.[1,7,8,21,23,24] This reduces costs for patients and allows the hospital beds to be used for other trauma patients.

The mean number of dressings used in the SSD group was greater than in the Xenoderm group. Twenty-three (58.9%) patients in the Xenoderm group did not use dressings after using Xenoderm. However, in cases of infection, the number of dressings increased. Daily dressing changes are very painful.[12] Kumar et al suggested that fewer dressings would be required in partial-thickness burns in children if synthetic dressings were used.[7] Other studies have reported that pig skin has pain-relieving effects on burns patients.[11,13,16,21,25] Therefore, with fewer dressing changes for burns, patients would be more satisfied and more comfortable during treatment, and these good results would be enhanced by less use of analgesics.

Finally, our results showed that there was a significant difference in the number of oral analgesics used between the two groups. It was found that 62% of the patients in the SSD group and 23% of the patients in the Xenoderm group needed not more than six doses of oral analgesics. The low use of oral analgesics in the Xenoderm group may be due to the fact that Xenoderm adheres to the wounds and decreases pain, infection rate and number of dressings used.[7,9,10,14,26] This has been well documented in previous studies.[27,28]

Conclusion

Our study suggests that using a biological dressing (Xenoderm) can be a good and feasible approach in treating partial-thickness burns. Based on our clinical experience, Xenoderm seems to be more effective than SSD in terms of pain control, wound infection, number of wound dressings and length of hospital stay

in partial-thickness burns. Prospective randomised studies are now necessary to determine the possibility of reducing STSG use and assessing re-epithelialisation time.

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References

1. Potokar T. Paediatric burn injuries—tomorrow is too late. *Burns* 2005;31:401.
2. Maghsoudi H, Samnia N. Etiology and outcome of pediatric burns in Tabriz, Iran. *Burns* 2005;31:721–5.
3. Brunicardi FC, Andersen DK, Billiar TR, et al, eds. *Schwartz's Principles of Surgery,* 8th edition. New York: McGraw-Hill, 2005: 189–221.
4. Barret JP, Dziewulski P, Ramzy PI, et al. Biobrane versus 1% silver sulfadiazine in second-degree pediatric burns. *Plast Reconstr Surg* 2000;105:62–5.
5. Gomez R, Cancio LC. Management of burn wounds in the emergency department. *Emerg Med Clin North Am* 2007;25:135–46.
6. Kearney JN. Banking of skin grafts and biological dressings, In: Settle JAD, ed. *Principles and Practice of Burns Management*. New York: Churchill Livingstone, 1996:329–51.
7. Kumar RJ, Kimble RM, Boots R, et al. Treatment of partial-thickness burns: a prospective, randomized trial using Transcyte. *ANZ J Surg* 2004;74:622–6.
8. Costaglioa M, Agrosi M. Second-degree burns: a comparative, multi-center, randomized trial of hyaluronic acid plus silver sulfadiazine vs. silver sulfadiazine alone. *Curr Med Res Opin* 2005;21:1235–40.
9. Townsend CM, Beauchamp RD, Evers BM, et al, eds. *Sabiston Textbook of Surgery: The Biological Basis of Modern Surgical Practice,* 17th edition. Philadelphia: Elsevier Saunders, 2004:582–3.
10. Chiu T, Burd A. Xenograft dressing in the treatment of burns. *Clin Dermatol* 2005;23:419–23.
11. Chiu T, Pang P, Ying SY, et al. Porcine skin: friend or foe? *Burns* 2004;30:739–41.
12. Kiene S, Schill H, Roewer J, et al. Lyophilized split pigskin as biological wound dressings, original treatises. *Zentralbl Chir* 1976; 101:1481–94.
13. May SR. The effect of biological wound dressing on the healing process. *Clin Mater* 1991;8:243–9.
14. Becker D. Temporary wound dressing of burns with fresh, sterile, frozen porcine skin. *Ann Burns Fire Disasters* 1998;10: 171–5.
15. Schmitt W. Die lokalbehandlung der verbrennungswunden. *Zentralbl Chir* 1973;98:320–4.
16. Hosseini SN, Mousavinasab SN, Fallahnezhad M. Xenoderm dressing in the treatment of second degree burns. *Burns* 2007; 33:776–81.
17. Castellano JJ, Shafii SM, Ko F, et al. Comparative evaluation of silver-containing antimicrobial dressings and drugs. *Int Wound J* 2007;4:114–22.
18. Chatterjee DS. A controlled comparative study of the use of porcine xenograft in the treatment of partial thickness skin loss in an occupational health center. *Curr Med Res Opin* 1978;5: 726–33.
19. Klein L, Mericka P, Preis J. Clinical experience with skin senografts in burned patients. In: Masellis M, Gunn SWA, eds. *The Management of Burns and Fire Disasters: Perspectives 2000.* Dordrecht: Kluwer Academic Publishers, 1995:337–45.
20. Artz CP, Rittenbury MS, Yarbrough DR. An appraisal of allografts and xenografts as biological dressings for wounds and burns. *Ann Surg* 1972;175:934–8.
21. Gravante G, Delogu D, Giordan N, et al. The use of Hyalomatrix PA in the treatment of deep partial-thickness burns. *J Burn Care Res* 2007;28:269–74.
22. Caruso DM, Foster KN, Blome-Eberwein SA, et al. Randomized clinical study of Hydrofiber dressing with silver or silver sulfadiazine in the management of partial-thickness burns. *J Burn Care Res* 2006;27:298–309.
23. Still JM, Law EJ, Blecher K, et al. Decreasing length of hospital stay by early excision and grafting of burns. *South Med J* 1996; 89:578–82.
24. Chiu T, Shah M. Porcine xenograft dressing for facial burns: beware of the mesh imprint. *Burns* 2002;28:279–82.
25. Gerding Rl, Emerman CL, Effron D, et al. Outpatient management of partial-thickness burns: Biobrane versus 1% silver sulfadiazine. *Ann Emerg Med* 1990;19:121–4.
26. Pruitt BA Jr, Levine NS. Characteristics and uses of biologic dressings and skin substitutes. *Arch Surg* 1984;119:312–22.
27. Rappaport I, Pepino AT, Dietrick W. Early use of xenografts as a biologic dressing in burn trauma. *Am J Surg* 1970;120: 144–8.
28. Hopper RA, Knighton J, Fish J, et al. Use of skin substitutes in adult Canadian burn centres. *Can J Plast Surg* 1997;5:112–7.